

Planning a Cloud Migration Effort

Cost Estimating Considerations

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Demystifying the Cloud – Key Definitions

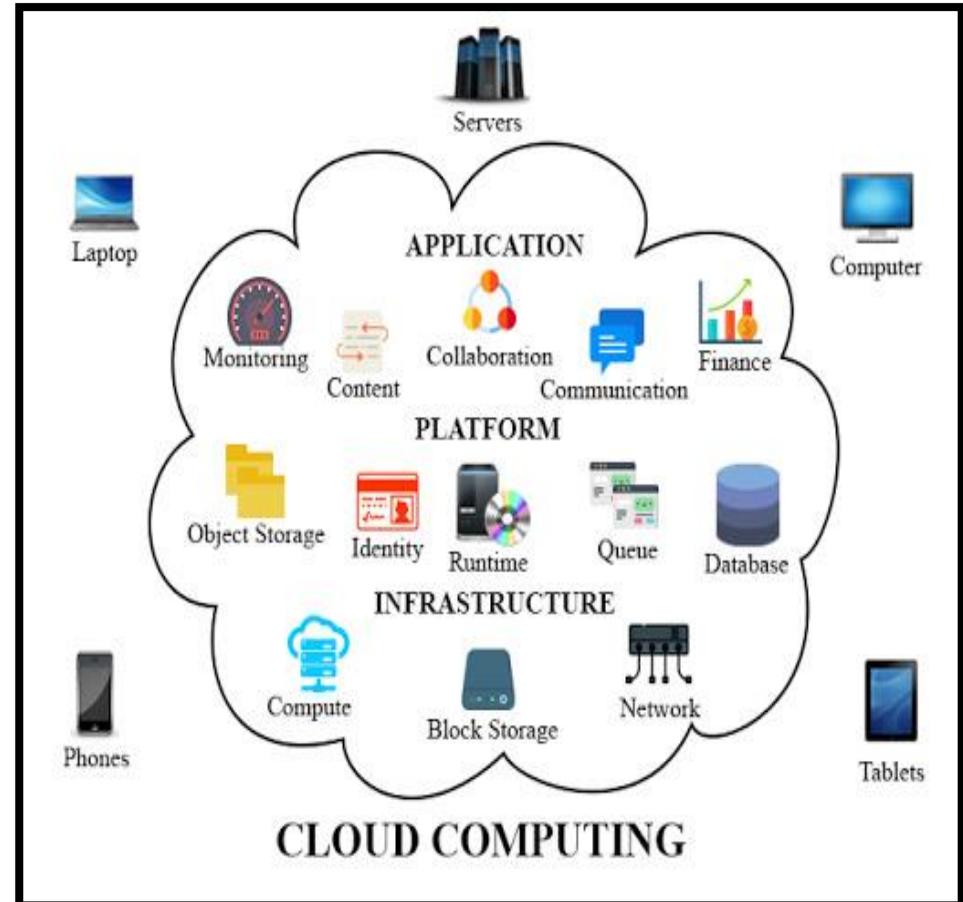
- Cloud computing describes the management of IT resources, most commonly via the internet, by third-party service providers for the benefit of customers
- Cloud services allow for real-time data storage and distribution within customized online environments, which cloud service providers (CSPs) design based on the operational needs of a customer
- The concept of the Cloud can be understood as fully-developed IT infrastructure which customers pay to utilize as a web-based service

Demystifying the Cloud

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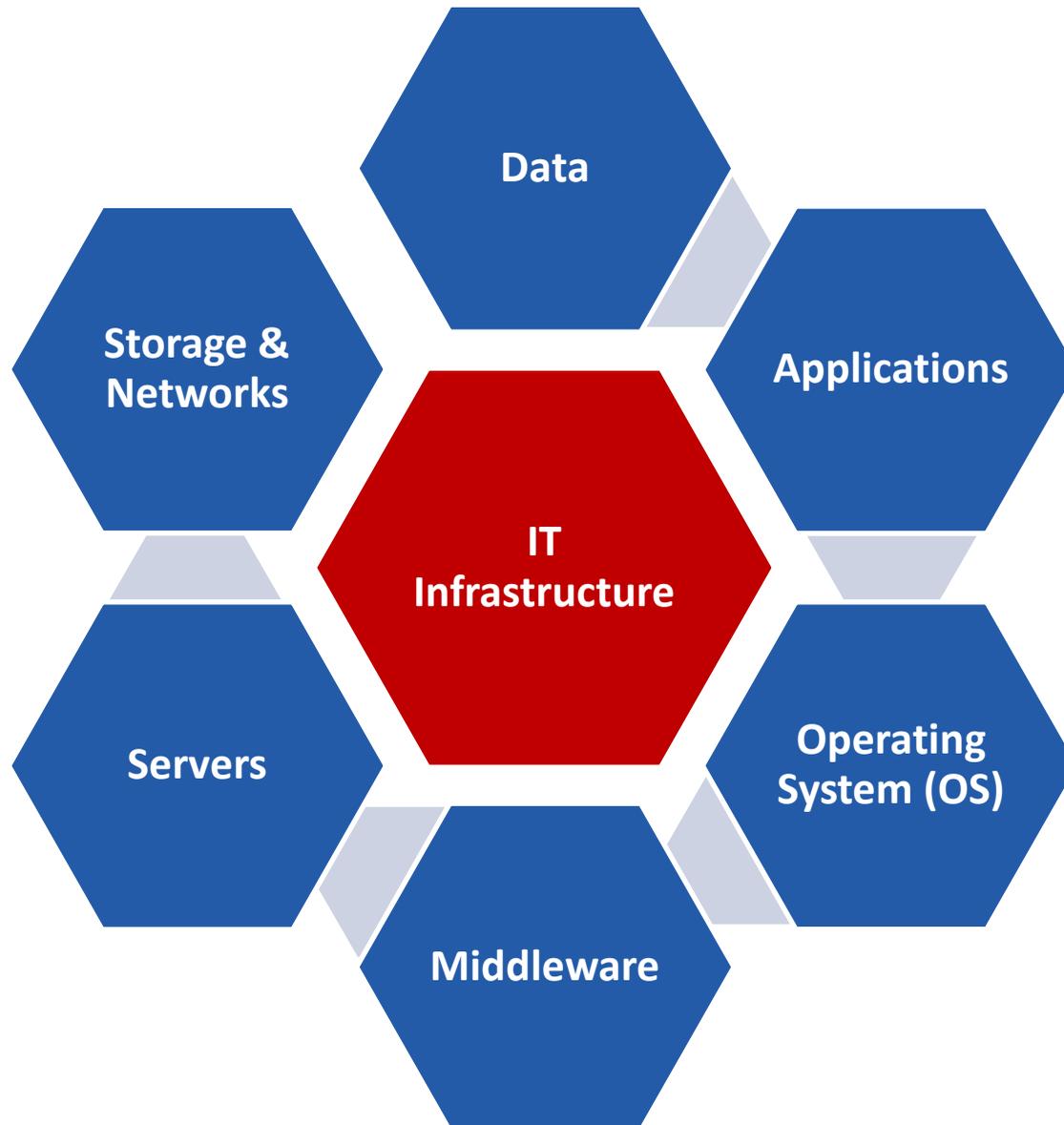
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Conceptual Diagram of IT Infrastructure



Question #1

- **Which of the following explains why organizations decide to migrate to a Cloud environment?**
 1. Reduce IT infrastructure costs
 2. Lack of appropriate IT resources for changing industry/mission demands
 3. Faster and more reliable data processing
 4. Improved data sharing and remote access capabilities
 5. All of the above

Question #1 - Answer

- **Which of the following explains why organizations decide to migrate to a Cloud environment?**
 1. Reduce IT infrastructure costs
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 3. Faster and more reliable data processing
 4. Improved data sharing and remote access capabilities
 - 5. *All of the above***

Why Utilize the Cloud?

- An organization's decision to procure Cloud services can be driven by several factors:
 - Lack of resources to develop/maintain robust IT infrastructure
 - Need for faster and more reliable data processing
 - Need for increased cybersecurity compliance
 - Disposition of legacy IT infrastructure
 - Extensive legacy hardware/software refresh requirements
- In comparison to legacy IT infrastructure, Cloud services offer greater speed, flexibility, and long-term cost efficiency due to highly adaptable Network Operating Systems (NOS)

Cloud Service Models

- A variety of Cloud service models are available to address specific customer objectives and accommodate their current IT capabilities:

Software as a Service (SaaS)	Provides the customer with Commercial-off-the-Shelf (COTS) software within an established Cloud platform
Platform as a Service (PaaS)	Provides the customer the capability to develop and deploy customized applications within an established Cloud infrastructure
Infrastructure as a Service (IaaS)	Provides the customer with a customized Cloud infrastructure, complete with processing, storage, network, and other computing capabilities that grant control over the development and deployment of IT resources

- Each Cloud model grants users the ability to store and distribute data using web-based infrastructure, but offers varying degrees of control over server deployment and management

Understanding Cloud Service Models

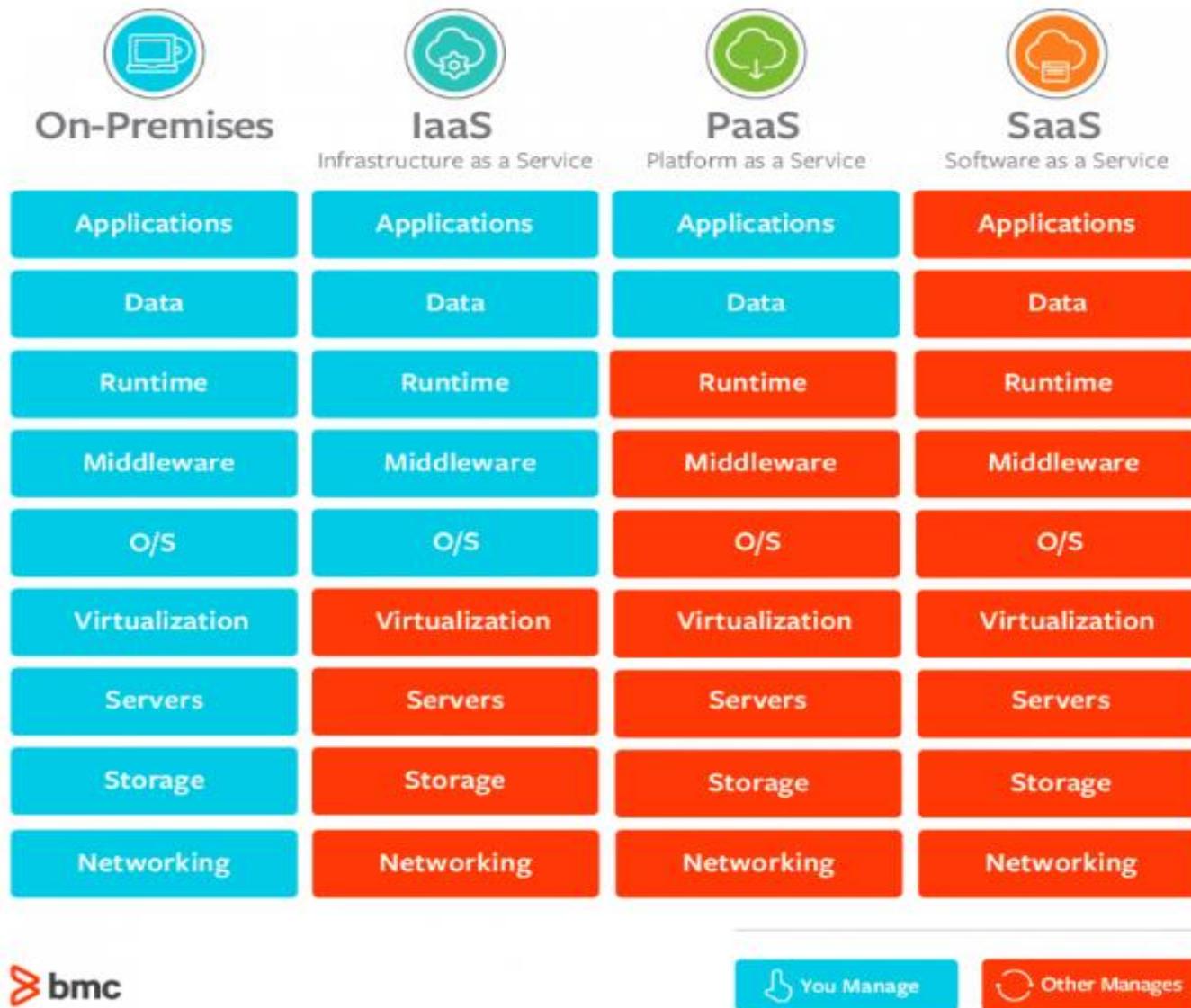


Image Source: "SaaS vs PaaS vs IaaS: What's the Difference and How to Choose". Link: <https://www.bmc.com/blogs/saas-vs-paas-vs-iaas-whats-the-difference-and-how-to-choose/>

Examples of Cloud Service Models

Platform Type	Common Examples
SaaS	Google Apps, Dropbox, Salesforce, Cisco WebEx, Concur, GoToMeeting
PaaS	AWS Elastic Beanstalk, Windows Azure, Heroku, Force.com, Google App Engine, Apache Stratos, OpenShift
IaaS	DigitalOcean, Linode, Rackspace, Amazon Web Services (AWS), Cisco Metapod, Microsoft Azure, Google Compute Engine (GCE)

Image Source: "SaaS vs PaaS vs IaaS: What's the Difference and How to Choose". Link: <https://www.bmc.com/blogs/saas-vs-paas-vs-iaas-whats-the-difference-and-how-to-choose/>

Cloud Deployment Models

- In addition to Cloud service models, organizations must also consider the viability of different Cloud deployment models in relation to enterprise agility, security, and life cycle cost requirements
- An organization's purpose and mission play key factors in determining an appropriate Cloud deployment model
 - For example, certain deployment features which prove beneficial for one organization (i.e. private business) may not be applicable or relevant for another (i.e. government agency)

Private Cloud

- Private Cloud deployment models are commonly provided via a private internal network (i.e. intranet), offering a compartmentalized IT environment available only to selected users
- Ideal for organizations with specific security, data governance, and compliance requirements which are too sensitive to manage in a public domain
- Challenges associated with Private Cloud deployment models include limited network scalability, decreased processing speeds, and the need for on premise data centers with higher maintenance costs

Public Cloud

- Public Cloud deployment models are provided via the public domain (i.e. internet), with CSPs offering customers developed IaaS in an on-demand marketplace
- Ideal for organizations seeking COTS solutions, or for organizations seeking cost savings associated with minimal IT infrastructure maintenance
- Challenges associated with Public Cloud deployment models include lack of fully customizable Cloud solutions, decreased control over data governance, and increased security risks due to data being transferred/housed within the public domain

Hybrid Cloud – “The Best of Both Worlds”

- Hybrid Cloud deployment models refer to the utilization of both public and private Cloud features to create a customized deployment solution, which ideally balances flexibility and decreased maintenance with security and increased data governance
- As the need for innovative IT solutions increases, Hybrid models are likewise becoming increasingly popular among organizations seeking to avoid Cloud vendor “lock-in”
 - Hybrid deployment models are conducive to the development of a Multicloud strategy, offering increased resiliency and migration opportunities in addition to the core benefits of the Cloud

Private, Public, and Hybrid Cloud Examples

	SaaS	PaaS	IaaS
Private Cloud	Cisco WebEx, Zoom for Government, Citrix GoToMeeting	Apprenda, AWS Elastic Beanstalk (AWS GovCloud)	IBM OpenStack, AWS GovCloud, Microsoft Azure Government
Public Cloud	Microsoft Office 365, Google Drive, RStudio Cloud	Microsoft SharePoint, Google Apps Engine, Kubernetes	Microsoft Azure, AWS, Oracle Cloud, IBM Cloud
Hybrid Cloud	Utilization of Public COTS SaaS, but monitored with customer's on premise security framework	Integration of Public PaaS templates within a private IaaS, with ability to transfer data to Public Cloud	Public IaaS managed by CSP, with compartmentalized servers, storage, and networking components managed directly by customer

Cloud Migration

- As organizations transition from legacy IT infrastructure to the utilization of Cloud services, the migration of data from legacy systems onto Cloud environments becomes a critical process
 - According to market research from Tripwire, Inc., the global size of the Cloud computing market is projected to grow from an estimated \$272 Billion in 2018 to an estimated \$623 Billion by 2023, at a CAGR of ~18%
- The development of a Cloud migration strategy accounting for enterprise IT objectives, existing infrastructure limitations, and available resources presents unique challenges for organizations
 - With Cloud implementation, there is no “one size fits all”

Cloud Migration Process



Cloud Migration Strategies

- Cloud migrations can vary in scope and complexity, ranging from the transfer of several data points across applications to large-scale migration efforts across multiple data centers
- The Six Common Strategies for Migration¹ offers an insightful summary into the various approaches to Cloud migration, allowing organizations to compare different approaches with projected IT demands

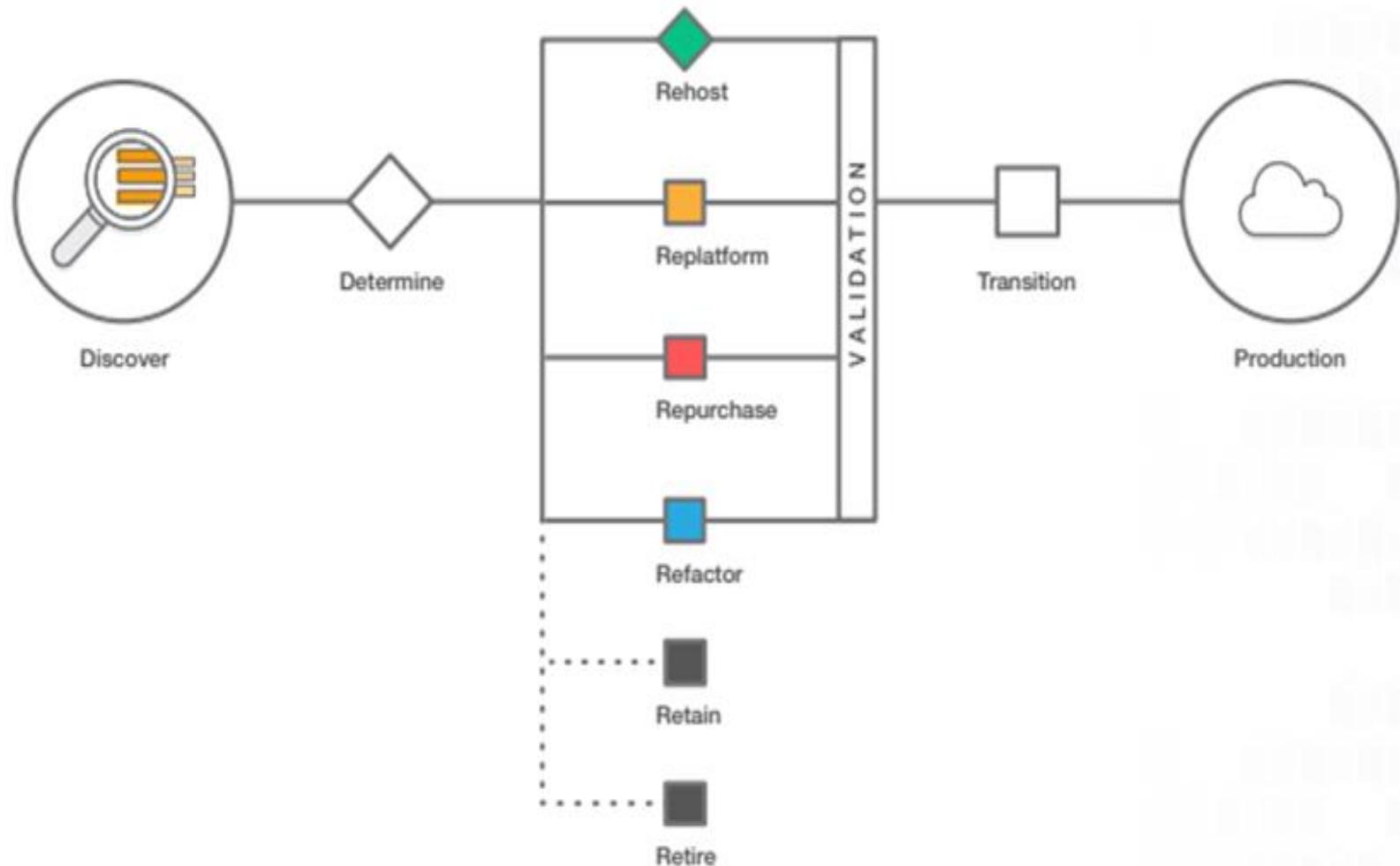
¹ Leveraged from “Migrating to AWS: Best Practices and Strategies”. Link: <https://aws.amazon.com/events/migration/webinars/whitepapers/>

The Six Common Strategies for Migration

RE-HOST ("Lift and Shift")	Migrate legacy data to ready-made Cloud platform, optimizing legacy data for Cloud environment
RE-PLATFORM ("Lift-Tinker-Shift")	Develop Cloud platform, then optimize legacy applications for Cloud platform
RE-PURCHASE ("Drop and Shop")	Dispose of legacy applications in favor of new Cloud-native applications
RE-FACTOR ("Tinker-Shift")	Re-design legacy application architecture by employing Cloud-native features, then shift onto Cloud environment
RETAIN	Consolidate, clean, archive, and optimize critical data points for future migration efforts
RETIRE	Prepare legacy data points/applications for disposition

Leveraged from "Migrating to AWS: Best Practices and Strategies". Link: <https://aws.amazon.com/events/migration/webinars/whitepapers/>

The Six Common Strategies for Migration



Six Common Migration Strategies: Condensed View Diagram

Leveraged from "Migrating to AWS: Best Practices and Strategies". Link: <https://aws.amazon.com/events/migration/webinars/whitepapers/>

Cloud Migration Strategies – Key Takeaways

- Organizations should understand how different Cloud migration strategies align with their enterprise IT objectives **BEFORE** contracting CSPs to facilitate a Cloud solution
- The adoption of a Cloud migration strategy that directly addresses IT capability gaps, resource limitations, and a projected Return On Investment (ROI) is fundamental for a successful migration outcome

Planning a Cloud Migration

- The Five Phase Migration Process² provides a top-down framework for planning a Cloud migration process, outlining requirements as well as factors to consider when reality-testing potential solutions
- Phases 1-3 encourage organizations to map and implement migration efforts for peripheral data in order to develop an improved strategy for target data. Phases 4-5 build upon lessons learned from preliminary migration efforts

² Leveraged from “Migrating to AWS: Best Practices and Strategies”. Link: <https://aws.amazon.com/events/migration/webinars/whitepapers/>

Planning a Cloud Migration

Five Phase Migration Process³

1. Migration Prep & Business Planning
2. Portfolio Discovery & Planning
3. Application Design
4. Migration & Validation
5. Operation

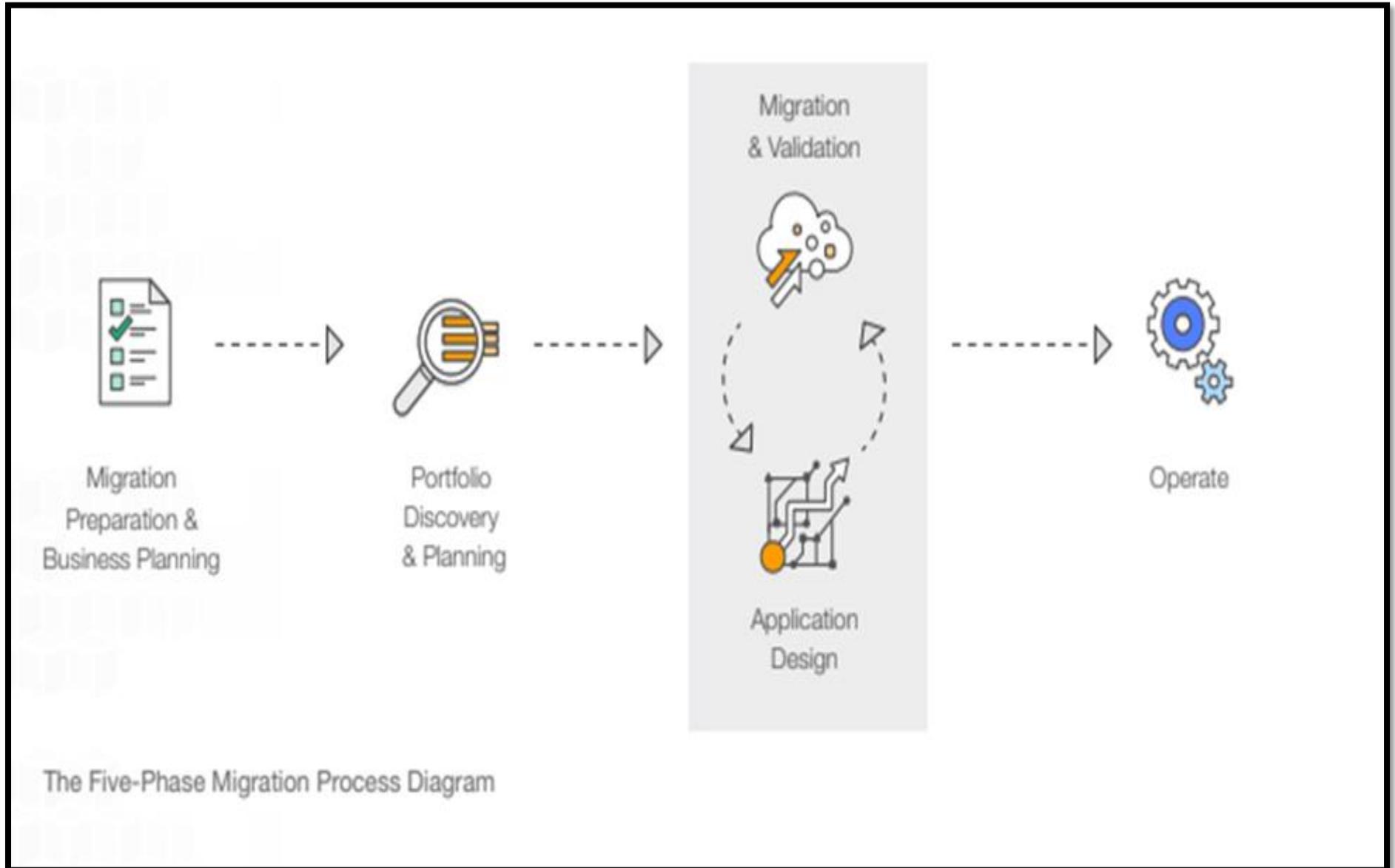
DoD Acquisition Framework⁴

1. Materiel Solution Analysis
2. Technology Development
3. Engineering & Manufacturing Development
4. Production & Deployment
5. Operations & Support

³ Leveraged from “Migrating to AWS: Best Practices and Strategies”. Link: <https://aws.amazon.com/events/migration/webinars/whitepapers/>

⁴ Leveraged from “Adaptive Acquisition Framework”. Link: <https://aaf.dau.edu/>

The Five Phase Migration Process



Leveraged from "Migrating to AWS: Best Practices and Strategies". Link: <https://aws.amazon.com/events/migration/webinars/whitepapers/>

Question #2

- **Which of the following represents the largest cost driver when migrating to a Cloud environment?**
 1. Disposition of legacy IT infrastructure
 2. Size dimensions of transferred data (i.e. storage costs)
 3. Data integration/validation costs
 4. Post-migration maintenance costs

Question #2 - Answer

- Which of the following represents the largest cost driver when migrating to a Cloud environment?
 1. Disposition of legacy IT infrastructure
 - 2. *Size dimensions of transferred data (i.e. storage costs)***
 3. Data integration/validation costs
 4. Post-migration maintenance costs

Cloud Migration – Cost Estimating Questions

- How will legacy data be migrated to the Cloud?
 - E.g. Re-hosted, Re-platformed, Re-factored, etc.? A realistic and in-scope cost estimate cannot be developed until this question is answered
- What will be the cost of integrating and testing recently migrated data points within a Cloud environment?
 - This is a critical factor, as legacy data points need to be integrated into Cloud infrastructure, then tested to ensure functionality
 - The cost risk of significant non-functional data will also need to be considered, as extensive re-factoring/disposition efforts may warrant a restructure or even reconsideration of a selected Cloud architecture
- Will certain legacy applications need to be retained while migrating other data points to the Cloud?
 - Retaining certain legacy application functionalities and the infrastructure that supports them during a migration process can drive up costs

Cloud Migration – Cost Estimating Overview

- When developing a Cloud migration strategy, important cost drivers for organizations to consider up-front include:
 - Size dimensions of data housed in legacy IT system
 - Amount of data points to be migrated onto Cloud environment
 - Data integration/validation costs prior to and following migration efforts
 - Maintenance costs associated with Help Desk and cybersecurity support
- It is important for organizations to understand overall Life Cycle Costs (LCCs) involved with a migration process – including but not limited to data auditing, consolidation, optimization, migration, integration, validation, maintenance, and eventual disposition

Preliminary Cost Estimating Steps

- Perform a Gap Analysis of legacy IT infrastructure compared to projected benefits of a Cloud solution
 - Organizations should have a clear understanding of what enterprise requirements are not being met by legacy IT infrastructure, and how the development of a Cloud solution will resolve these capability gaps along with a projected ROI
- Obtain a Rough Order of Magnitude (ROM) for proposed CSP solutions
 - Highly dependent on proposed Cloud deployment model, service model, and data migration strategy relative to the customer's objectives and capabilities
 - Several leading CSPs offer basic Cloud cost calculators equivalent to a ROM estimate for potential services
 - Specific quotes to include a Work Breakdown Structure (WBS) will most likely require a service agreement between an organization and CSP

Cost Considerations for Cloud Cybersecurity

- As advanced cybersecurity measures become necessary to protect Cloud infrastructure, features that mitigate data exploitation from ransomware and malware can significantly drive costs for Cloud migration and implementation
 - In addition to cybersecurity planning for future Cloud environments, it is necessary to ensure comprehensive security frameworks for legacy IT infrastructure, as a migration effort may require end-to-end monitoring of transferred data points
- Cybersecurity cost drivers to consider include:
 - Functional size metrics associated with the development of a standard or “glued” security framework for Cloud environments (especially if developing a Multicloud solution)
 - Operations & Maintenance costs associated with regular infrastructure audits, risk assessments, and countering active cyberattacks
 - Costs of developing/maintaining backup data centers in preparation for potential cyberattacks

Cloud Service Cost Considerations

Cost Drivers	Expected Cost Impact	Rationale
Server Utilization	▼	Higher utilization due to Virtualization
Storage Utilization	▼	Higher utilization due to Pooling and Virtualization
Hardware Procurement	▼	Use of commodity servers and disk-attached storage, and economies of scale
IT Staff	▼	Lower quantity due to homogeneity of environment, automation, tools, and economies of scale
Software Tools	▼	Economies of scale
Network Costs	▲	Additional bandwidth for connection to the Cloud
Facilities	▼	Due to higher equipment utilization by Cloud Provider
Power	▼	Due to higher equipment utilization by Cloud Provider
Transition Costs	▲	Applications modifications, changes in business processes

▼ Decreased cost compared to traditional IT
 ▲ Increased cost compared to traditional IT

Image Source: "Cost Element Structure for Cloud Migration Business Case Analysis". Link: <http://www.iceaaonline.com/ready/wp-content/uploads/2016/06/SS06-ppt-Cloud-Migration.pdf>

Cloud Migration WBS Considerations

- A Work Breakdown Structure (WBS) serves as a useful framework for organizations to estimate cost and schedule requirements for a Cloud service deployment and data migration process
- Although a Cloud service WBS will vary depending on an organization's objectives and capabilities, important cost components to examine include:
 - Quantity & complexity of desired service model(s)
 - Requirements for implementing specific service model(s)
 - Requirements to refactor/develop applications for a Cloud environment
 - Migration software requirements to migrate data onto Cloud-based applications
 - Recurring IT maintenance requirements to ensure Cloud service functionality

Cloud Migration WBS Considerations

- A preliminary Cloud WBS can be divided into 4 tiers, each describing a “top-down” approach to conceptualizing the entire acquisition process

Tier 0	Complete system to be acquired by an organization (e.g. IaaS model)
Tier 1	Necessary sub-systems considerations (e.g. capabilities, facilities, etc.)
Tier 2	Material components and labor necessary to facilitate sub-system requirements (e.g. hardware/software, labor, etc.)
Tier n	Effort considerations to satisfy sub-system requirements. Factors in all metrics necessary to evaluate acquisition progress (e.g. duration of efforts, allocation of labor, acquisition arrangements, etc.)

Leveraged from “Planning & Management Methods for Migration to a Cloud Environment”. Link: <https://www.mitre.org/sites/default/files/publications/pr-17-4029-planning-management-methods-migration-to-cloud-environment.pdf>

Cloud Service WBS Conceptual Diagram

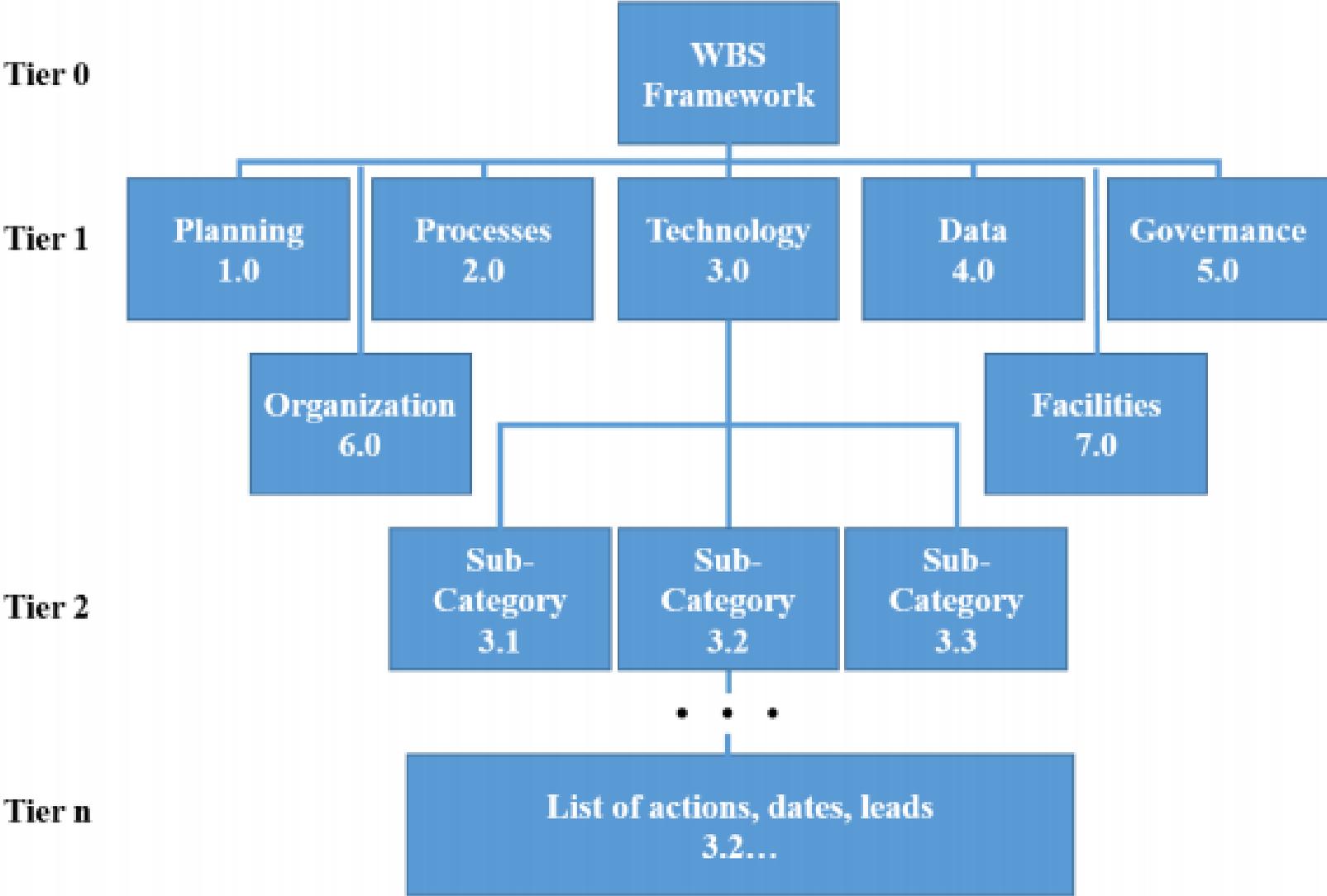


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In Conclusion...

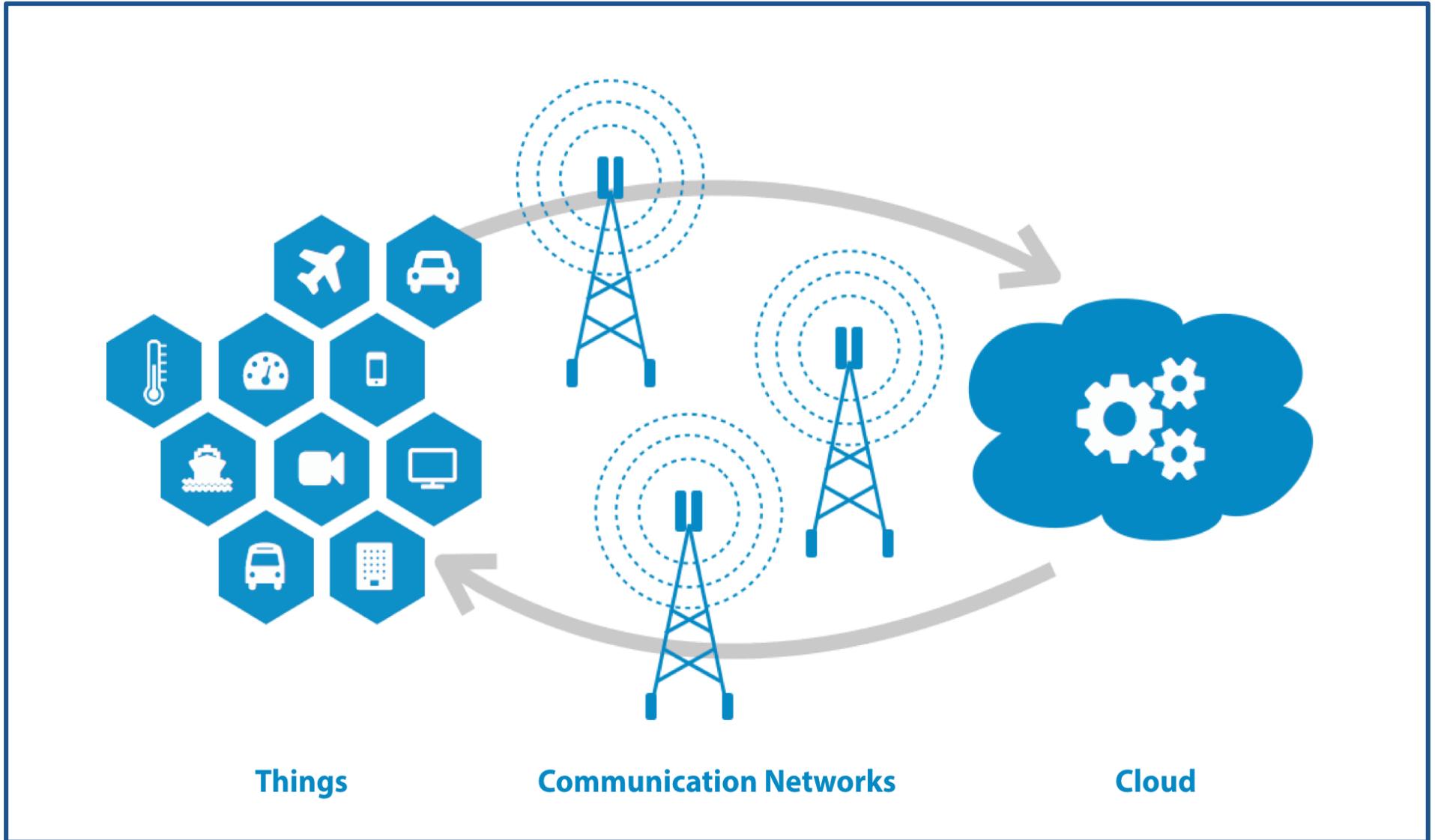
- Cloud migration costs can be large in the short-term, but organizations should also consider the long-term costs associated with maintaining legacy IT infrastructure for evolving data management efforts
- If planned effectively, long-term migration costs may provide organizations with a significant ROI, as many enterprise information systems are migrating to Cloud environments in order to meet shifting industry/mission requirements
 - Migrating data to Cloud environments can also ensure greater IT efficiency and flexibility for evolving missions

BACKUP

Edge Computing

- Edge computing positions data processing capabilities geographically closer to systems and their users in order to reduce network latency
- As the capacity and rate of data generated from Internet of Things (IoT) endpoints increases, more organizations will look to utilize edge computing in conjunction with their selected Cloud deployment model
- Edge and Cloud computing models can significantly complement each other, increasing the efficiency of data processing by incorporating the best of centralized and decentralized workflow models

Conceptual Diagram of Edge Computing



Cloud Myths

■ You need to utilize Cloud services to maintain relevancy

- Cloud services can offer organizations increased flexibility, agility, and data sharing/storage needs within a web-based environment
- However, organizations are not necessarily "behind the curve" if they don't utilize Cloud services
- In some instances, Cloud solutions may not address specific enterprise challenges, or may not comply with strict IT security requirements

■ Cloud should be used for *everything* IT

- Cloud is useful for managing unpredictable workloads or when improved network scalability is necessary
- Not all IT challenges call for Cloud solutions. Moving legacy applications onto the Cloud for the sake of "being in the Cloud" is not a viable strategy
- Organizations should have a well-developed rationale for seeking Cloud solutions

Cloud Myths

■ Multicloud strategies will prevent vendor “lock-in”

- Adopting a Multicloud strategy can help organizations diversify their portfolio of Cloud services and CSPs
- However, even if CSP X is only providing PaaS, an organization still depends on CSP X to maintain PaaS solutions. An appropriate level of CSP dependency should be evaluated prior to the procurement of services

■ *“Once I move to the Cloud, I’m done”*

- A functional Cloud strategy does not end post-migration
- Continuous re-factoring, system maintenance, and defect correction is necessary to ensure continuous capabilities of a Cloud solution
- Cybersecurity costs will likewise be a cost driver for Cloud maintenance

Cloud Myths

- **Many Cloud migrations run the risk of failure**
 - The success of a Cloud migration is almost entirely dependent on the preparation of an appropriate Cloud migration strategy in accordance with organizational objectives
 - The myth that many Cloud migration efforts are abandoned, and that many organizations end up repatriating data onto legacy systems is not accurate
 - It's much more likely that an organization will re-strategize Cloud solutions when faced with intractable migration challenges
- **Organizations should use one Cloud strategy or vendor**
 - A single CSP can rarely satisfy all the needs of an organization
 - Organizations should understand that their strategies may best be carried out through the incorporation of multiple service models or CSPs
 - "One size fits all" is not realistic

References

“How to calculate the true cost of migrating to the cloud”: <https://www.networkworld.com/article/3164444/how-to-calculate-the-true-cost-of-migrating-to-the-cloud.html>

“Migrating to AWS: Best Practices and Strategies.”: <https://aws.amazon.com/events/migration/webinars/whitepapers/>

“Exploring the factors influencing the cloud computing adoption: a systematic study on cloud migration.”: <https://rd.springer.com/article/10.1186/s40064-015-0962-2>

FedRAMP market website: <https://marketplace.fedramp.gov/#/products?status=Compliant&sort=productName>

“Cloud Migration: A Case Study of Migrating an Enterprise IT System to IaaS.”: <https://ieeexplore.ieee.org/abstract/document/5557962>

“A Novel Service Composition Approach for Application Migration to Cloud”: https://rd.springer.com/content/pdf/10.1007%2F978-3-642-45005-1_57.pdf

“Right Scaling for Right Pricing: A Case Study on Total Cost of Ownership Measurement for Cloud Migration”:
<https://arxiv.org/ftp/arxiv/papers/1908/1908.04136.pdf>

“Evaluating cloud database migration options using workload models”: <https://rd.springer.com/content/pdf/10.1186%2Fs13677-018-0108-5.pdf>

Cloud Migration Process – A survey, evaluation framework, and open challenges: <https://www.semanticscholar.org/paper/Cloud-migration-process-A-survey%2C-evaluation-and-Fahmideh-Daneshgar/08950a428dc314dd97d98d28712f5aa7b43cf712#extracted>

“Five Steps for Calculating AWS Cloud Migration Costs”: <https://www.clearscale.com/blog/calculating-cloud-migration-costs/>

“DoD Completes First App Migration to MilCloud 2.0”: <https://www.meritalk.com/articles/dod-completes-first-app-migration-to-milcloud-2-0/>

“Air Force turning to a service-oriented approach for IT applications”: <https://federalnewsnetwork.com/defense/2013/12/air-force-turning-to-a-service-oriented-approach-for-it-applications/>

“Air Force Speeds Ahead on Cloud Migration”: <https://fedtechmagazine.com/article/2018/06/air-force-speeds-ahead-cloud-migration>

Defense Information Systems Agency website: <https://storefront.disa.mil/kinetic/disa/service-catalog#/forms/milcloud>

“Army site gives cloud migration teams a leg up”: <https://gcn.com/articles/2018/01/05/army-aambo-cloud-migration.aspx>

Enterprise Computing Operations Service Center website: <https://ecosc.army.mil/Mission/>

Program Executive Office for Enterprise Information Systems (PEO EIS) website: <https://www.public.navy.mil/navwar/PEOEIS/Pages/AboutUs.aspx>

References

“New Navy goal: Move most IT systems to cloud by 2021”: <https://federalnewsnetwork.com/navy/2018/02/new-navy-goal-move-most-it-systems-to-cloud-by-2021/>

Navy ERP Program website: <https://www.erp.navy.mil/>

“Navy Completes Its Largest Cloud Migration to Date”: https://www.navy.mil/submit/display.asp?story_id=110670

“Navy marks its biggest commercial cloud transition to date”: <https://federalnewsnetwork.com/navy/2019/08/navy-marks-its-biggest-commercial-cloud-transition-to-date/>

“Planning & Management Methods for Migration to a Cloud Environment”: <https://www.mitre.org/sites/default/files/publications/pr-17-4029-planning-management-methods-migration-to-cloud-environment.pdf>

“Cost Element Structure for Cloud Migration Business Case Analysis”: <http://www.iceaaonline.com/ready/wp-content/uploads/2016/06/SS06-ppt-Cloud-Migration.pdf>

“Cost Computing Starter Kit: Cost and Business Case Considerations”: http://www.iceaaonline.com/ready/wp-content/uploads/2017/09/ET-7_Presentation_CloudComputingStarterKit-CostBusinessCaseConsiderations_Agrawal.pdf

SOW Template for IaaS or PaaS. https://www.doi.gov/sites/doi.gov/files/uploads/iaas-paas_statement_of_work_sow_ver_1.0.pdf

“How to migrate to SaaS applications”: https://www.dxc.technology/enterprise_and_cloud_apps/insights/146381-how_to_migrate_to_saas_applications

“Migration to PaaS Clouds – Migration Process and Architectural Concerns”: <https://core.ac.uk/download/pdf/16754838.pdf>

“6 Steps for Planning a Cloud Strategy”: <https://www.gartner.com/smarterwithgartner/6-steps-for-planning-a-cloud-strategy/>

“Modernize IT Infrastructure in a Hybrid World”: <https://www.gartner.com/smarterwithgartner/modernize-it-infrastructure-in-a-hybrid-world/>

“Edge Computing vs. Cloud Computing: Key Differences”: <https://phoenixnap.com/blog/edge-computing-vs-cloud-computing>

“Why Organizations Choose a Multicloud Strategy”: <https://www.gartner.com/smarterwithgartner/why-organizations-choose-a-multicloud-strategy>

“The Top 10 Cloud Myths”: <https://www.gartner.com/smarterwithgartner/the-top-10-cloud-myths/>

“4 Trends Impacting Cloud Adoption in 2020”: <https://www.gartner.com/smarterwithgartner/4-trends-impacting-cloud-adoption-in-2020/>